FREQUENCY & TIMING

DSN Time and Frequency Requirements for Cassini Radio Science

John Dick

Advanced frequency standards and distribution requirements for DSN support of the Cassini Radio Science mission include short- and mid-term stability requirements for gravitational wave tests (in place by December 2000), and very strict short-term stability and phase noise requirements for occultation experiments after orbit insertion (by October 2003). The presently installed DSN frequency standards capability is marginal with respect to meeting gravitational-wave stability requirements, and does not meet either the frequency stability or phase requirements needed by October 2003. However, the requirements can be met by incorporating the JPL-developed Superconducting Cavity Maser Oscillator (SCMO) frequency standard, together with a feedback-stabilized fiber optic reference frequency distribution system (Stabilized FODA). The linear ion trap standards (LITS), which will be installed in the DSN by that time, provide a margin of safety for the longer term stability requirements (τ = 10,000 s and longer).

Short-term stability and phase noise performance for the hydrogen maser is primarily determined and limited by its approximately 1 picowatt maser output power, which is corrupted at these short times by room temperature and follower amplifier noise. Because of this, the DSN hydrogen-maser package comprises not just the maser, but also a high-quality quartz crystal follower oscillator for short-term stability ($\tau < 0.1$ s) and phase noise performance. Operating at a power level 1000 times higher, the SCMO shows a corresponding $\sqrt{1000}$ ~ factor-of-30 improvement in short-term performance, and gives phase noise that is substantially lower than that of the best crystal oscillators.

Because the SCMO operates at 1.5 K, cooled by liquid helium, it presently requires substantial operator attention, with liquid helium transfers required approximately every week. The DSN Technology Program work is currently focused on development of an SCMO capability operating at temperatures above 10 K, thus enabling the use of a small, closed-cycle refrigerator for cooling.

The new units will use a sapphire whispering-gallery microwave resonator instead of the present lead-plated sapphire TE_{011} mode resonator. This new resonator allows the high Q of the sapphire to be utilized without the need for superconducting film to contain the microwave fields. Thus, the whispering-gallery resonator technology is also more reliable in resonator Q performance. Installation of an SCMO capability is planned for the DSS 25 antenna pedestal to provide the required 3 to 4 x 10^{-15} frequency stability for measuring times $1\ \text{s} \leq \tau \leq 100$ s. These values are up to 25 times better (at $\tau = 1$ s) than the present hydrogen masers. Stabilized FODA frequency distribution will bring the improved frequency stability to SPC 10. Phase noise requirements of –68 dBc (/Hz) at Ka band for offset frequencies $1\ \text{Hz} \leq \Delta f \leq 10{,}000$ Hz are also met by this new capability. This compares to a presently installed performance of –50 dBc (/Hz) at 1-Hz offset. Installation of additional SCMO units is optionally planned for SPC 10 and for the overseas stations in order to make

CONTINUED ON NEXT PAGE

Keep tabs on recent events related to the DSN Technology Program by connecting to our WorldWideWeb home page.

In This Issue continued from page 1

leading to defocusing of the RF beam and loss of antenna aperture efficiency. A unique characteristic of the array feed is that it simultaneously provides real-time, adaptive corrections to both pointing errors and beam defocusing.

In our second article, Steve Johnson (Spacecraft Systems Engineering, Section 313) describes SURFSAT, a low-cost spacecraft designed and built largely by college students, working side-by-side with JPL mentors. SURFSAT, currently slated for launch in September '95, will transmit X- and Ka-band beacon signals, allowing better characterization of Ka-band link performance and providing extended experience with this new DSN frequency. SURFSAT will also test the X- and Ku-band links for the DSN's new 11-m antennas, a key element of future Very Long Baseline Interferometry (VLBI) space missions.

The final two articles focus on the time and frequency standards being developed by the DSN in the Tracking Systems and Applications Section (335), yielding the world's best frequency stability over a wide range of integration times. John Dick describes how these frequency standards enable many of the ambitious Radio Science experiments planned for the Cassini mission. And John Prestage describes how a long-term test of a new frequency standard for the DSN Linear Ion Trap provided data that place new constraints on the temporal variation of a key fundamental parameter of nature: the electromagnetic coupling constant. This serendipitous discovery, which represents an important step forward in fundamental physics and cosmology, reflects the rich interconnections between state-of-the-art science and many of the unique technologies which make up the DSN.

If you'd like to keep tabs on recent events related to the DSN Technology Program, you're invited to connect to our World Wide Web home page at: http://www331.jpl.nasa.gov/DSNTechProg/DSNTechProg.html.

In addition to our quarterly newsletters, you will find weekly updates of significant events and links to other DSN areas of interest (including the electronically accessible *TDA Progress Reports*). We plan to continue updating the information on the home page regularly, so check in periodically and see what's new.

DSN Requirements continued from page 7

the improved phase noise performance available to experimenters at these sites.

The FODA is an implementation version of the fiber-optic distribution technology developed at JPL under the DSN Advanced Systems program. The stabilized FODA requires the implementation of a new scheme to ensure that the frequency distribution system does not degrade the stability of signals generated by the ultrastable standards. The frequency stability requirements for the Cassini mission represent a significant opportunity to upgrade DSN capability and to make a new level of performance available for other radio science missions. It can provide the foundation necessary for a new capability in scientific exploration.

The *DSN Technology Program News* is a quarterly publication of JPL's Telecommunications and Mission Operations Directorate. The DSN Technology Program is managed by Chad Edwards.

Managing Editor .... Dr. Laif Swanson
Associate Editor .... George E. Shultz
Design and Layout .... Robin Dumas

JPL

Jet Propulsion Laboratory
California Institute of Technology

JPL D-12378 6/95